



Johnson Matthey
Catalysts

DIESEL EMISSION CONTROL

9 July 2008

**NOx Control with Retrofits:
California Emerging Clean Air Technology Forum
Merced, California**

**Marty Lassen
Director – Commercial Development & Marketing**



Diesel Engines

- Good Power
- High Efficiency
- Low Cost to Operate / Maintain
- Emissions
 - PM, HC, CO
 - NOx
- Lean-Burn Engines
 - Control PM, HC and CO Emissions with One Set of Technologies
 - Control NOx with a Different Set of Technology



Technology

- Diesel Oxidation Catalysts – LSD / ULSD
 - 25 to 50% PM, 60+% CO / HC Reduction
- “Partial” Flow Filters – LSD / ULSD
 - 50 to 70% PM, 60+% CO, HC Reduction
- Passive Filters - ULSD
 - >85% PM, 90%+ CO / HC Reduction
- Active Filters – LSD / ULSD
 - >85% PM, 0% CO / HC Reduction
- LNC - LSD w/ DOC, ULSD w/ DPF
 - 15 to 25% NOx, 25 - 85% PM, 60 - 90% CO / HC Reduction
- EGR – LSD w/ DOC, ULSD w/ DPF
 - 40 to 50% NOx, 25 - 85% PM, 60 - 90% CO / HC Reduction
- SCR – LSD w/ DOC, ULSD w/ DPF
 - 60 to 90% NOx, 25 - 85% PM, 60 - 90% CO / HC Reduction



Controlling PM, HC and CO

- DOC's, Partial Filters, DPF's
 - Oxidation Process for HC and CO
 - Capture and Oxidation of Soot

Controlling NOx

- EGR
 - Recirculation of Exhaust to Lower Temperature in Cylinder
- LNC, LNT, SCR
 - Use of Reductant (Diesel Fuel or Urea)



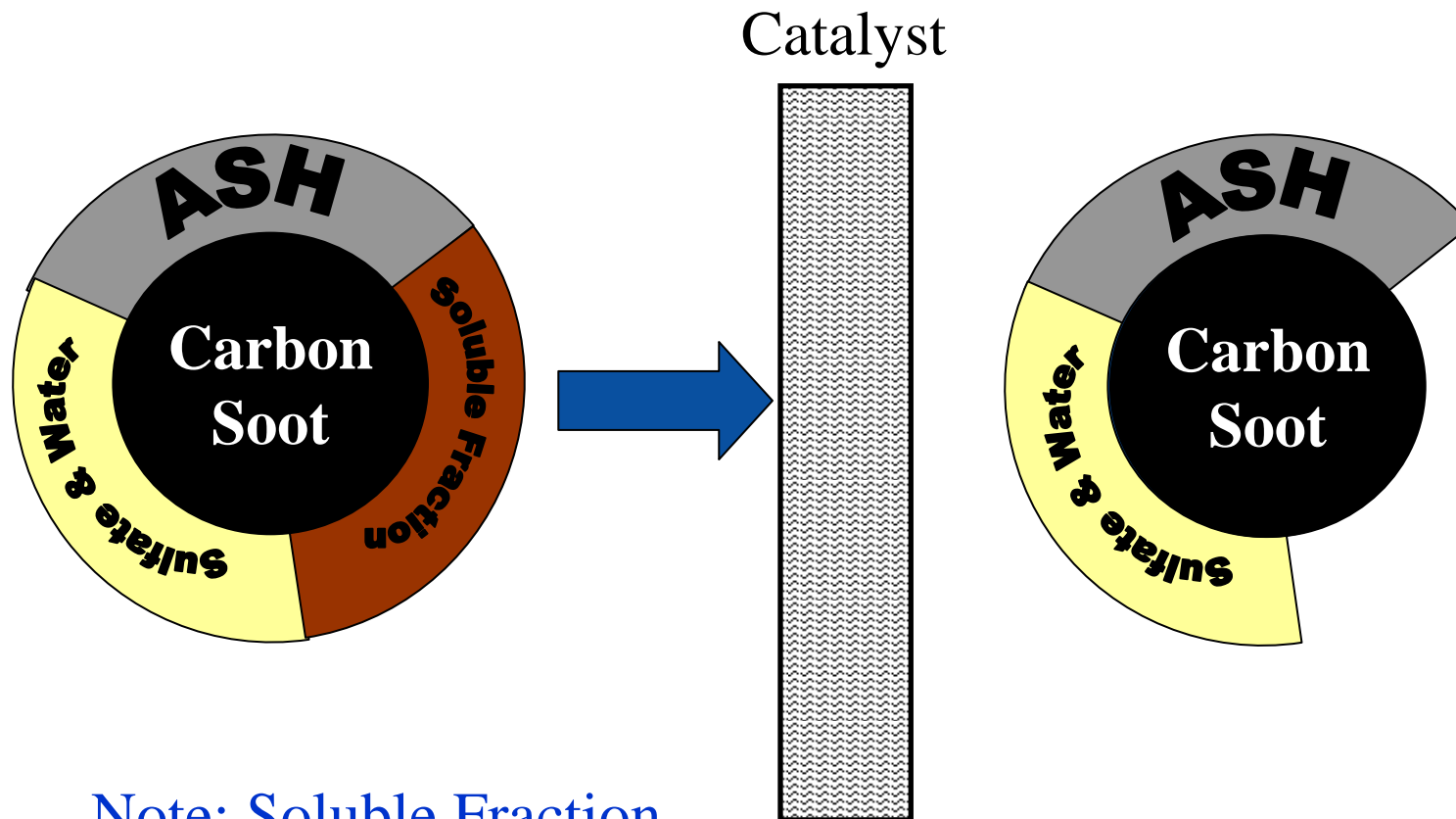
TECHNOLOGY OPTIONS AND BENEFITS



Controlling PM, HC and CO



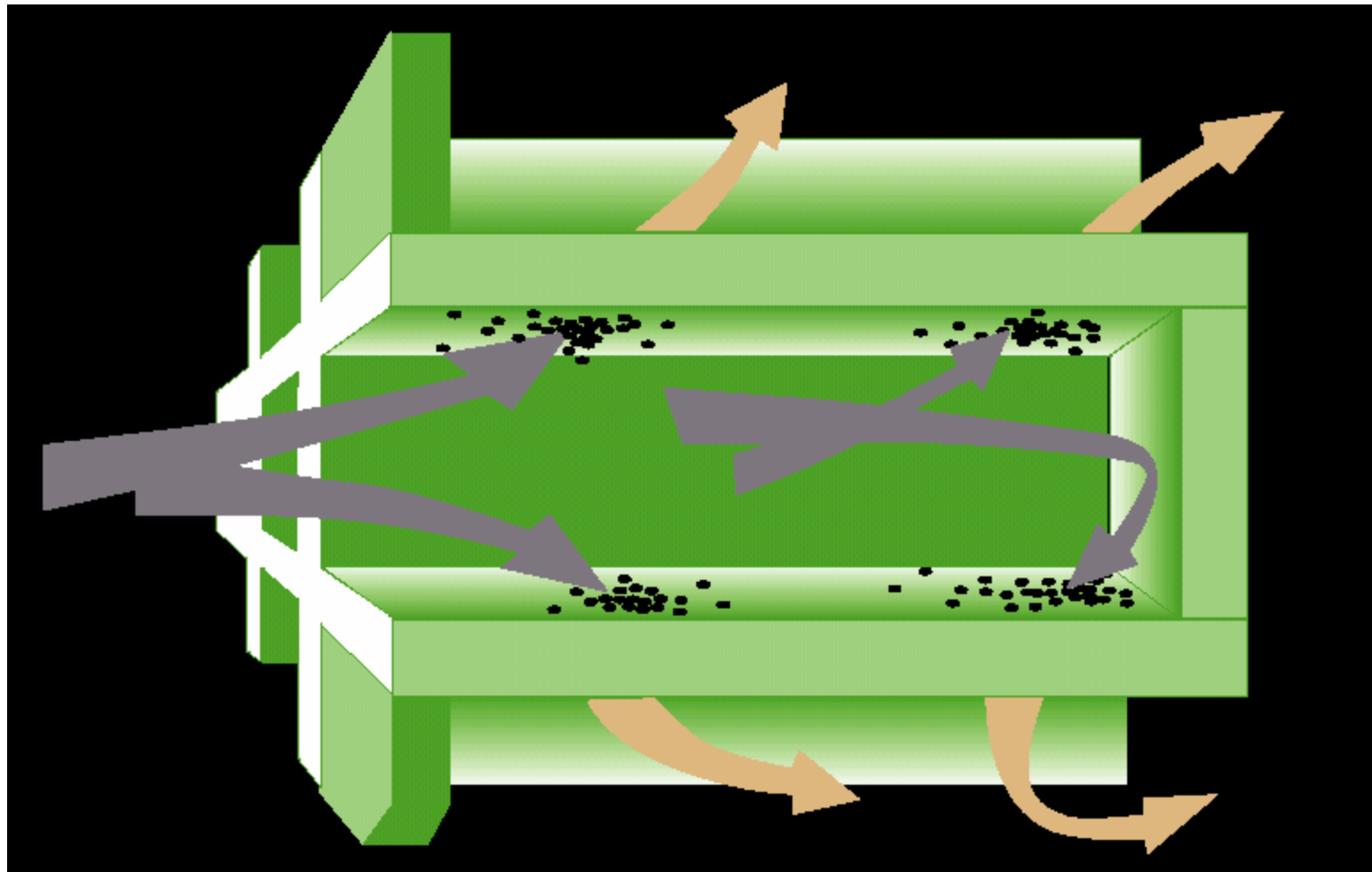
Particulate Matter Oxidation



Note: Soluble Fraction,
Sulfates and Water are in
Vapor form.



Particulate Filter - Wall Flow Filter



TECHNOLOGY OPTIONS AND BENEFITS



Controlling NOx



Exhaust Gas Recirculation (EGR)

- Recirculates engine exhaust back into the combustion chamber to lower temperature in cylinder reducing NOx
- Two Strategies
 - Low pressure, cooled EGR – takes exhaust after it has been through a DPF reintroducing clean exhaust into the combustion chamber: 40 – 60% NOx reduction for retrofit
 - High pressure EGR – takes exhaust directly from engine out: 30 – 70% NOx reduction for new engine applications



Lean NOx Catalysts (LNC)

- A flow through catalyst that reduces NOx with the injection of diesel fuel over the catalyst, aka, HC SCR.
- LNC catalyst are very temperature dependent
 - Platinum for low temperature
 - Zeolites for higher temperature
- Retrofit systems usually require both types for about a 20 – 25% NOx reduction with 4 – 8% fuel penalty



Lean NOx Traps (LNT)

- A flow through catalyst that adsorbs NOx on to its surface during normal (lean) operation and cycles to rich operation, releasing the stored NOx which is reduced by a separate catalyst layer.
- LNT catalyst contain high levels of Platinum and Rhodium
- LNT are sensitive to even the lowest amount of sulfur in the fuel and must be periodically “regenerated” by raising the exhaust temperature
- LNT technology is not a retrofit solution
- LNT technology is applicable to LHD and MHD new engines



Selective Catalytic Reduction (SCR)

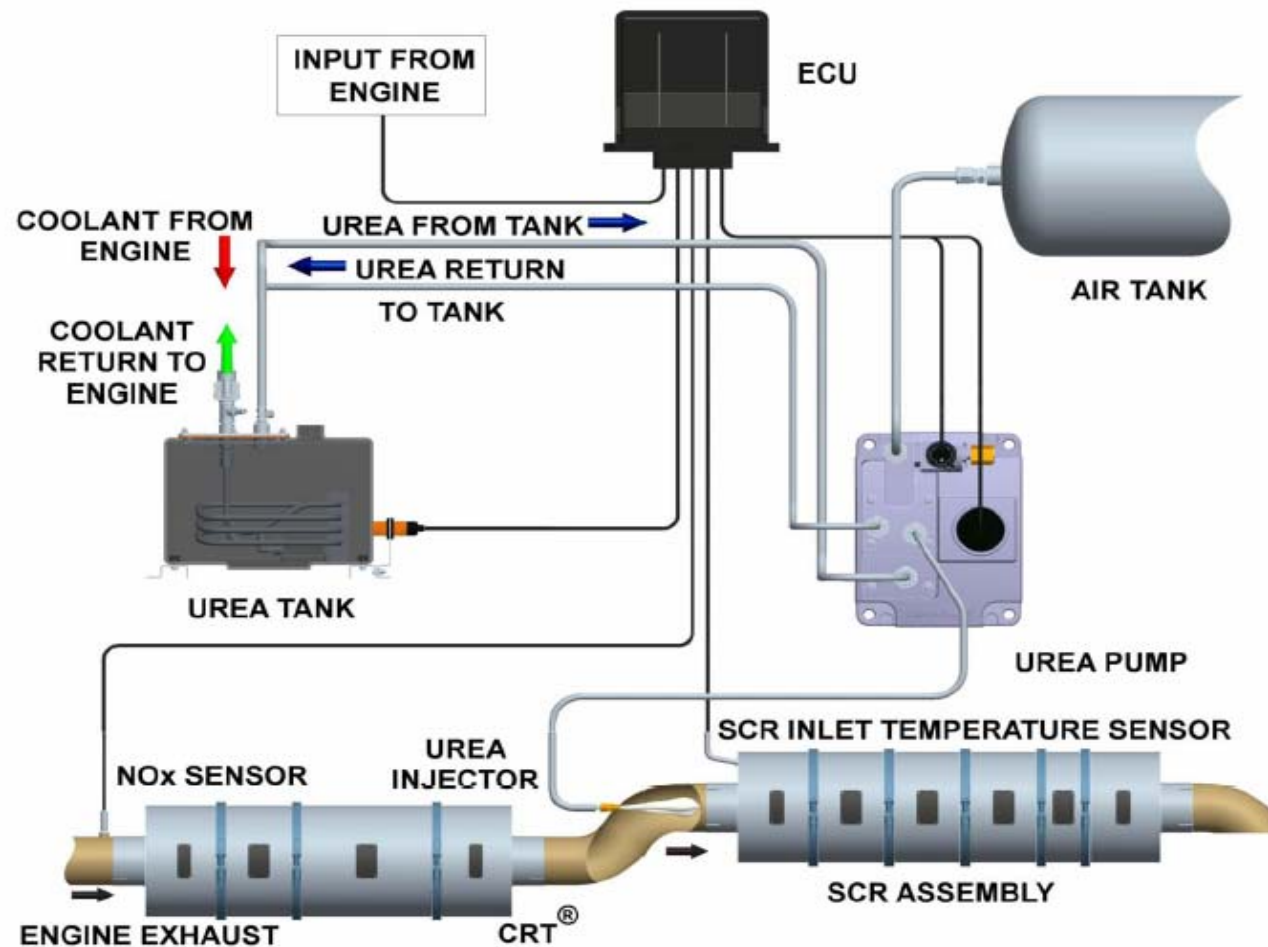
- A flow through catalyst that requires ammonia for reduction of NOx by 50 – 90%+
- Currently all systems inject urea which is converted to ammonia when injected into the exhaust stream
- SCR catalyst typically contain no precious metals
- SCR is a mature, commercial technology that has been used in stationary applications for over 30 years
- SCR technology is applicable to LHD, MHD and MHD new engines and is the likely solution for a number of MHD and HHD platforms in the US
- SCR only systems are in use for Euro 4 and Euro 5 engines
- SCR technology is a retrofit solution and several systems are in verification with the EPA and CARB



TECHNOLOGY OPTIONS AND BENEFITS



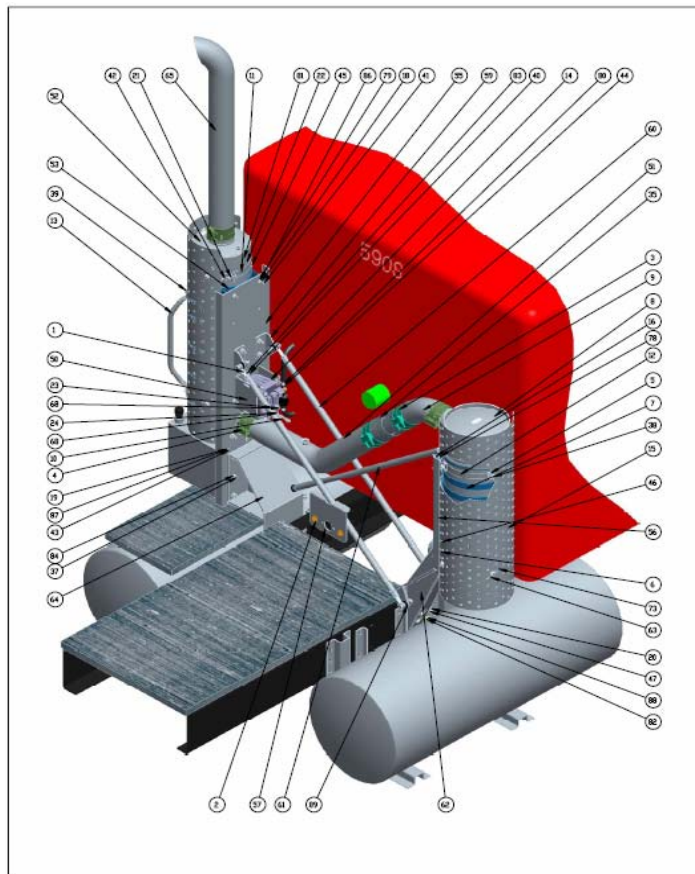
Selective Catalytic Reduction (SCR)



TECHNOLOGY OPTIONS AND BENEFITS



Selective Catalytic Reduction (SCR)



Selective Catalytic Reduction (SCR)

- System Description
- All systems will use STT Controller, Grundfos Urea Dosing System and Siemens NOx sensor
 - 4.0 g NOx System
 - CRT + Vanadium SCR + Ammonia Slip Catalyst
 - 2.5 g NOx System
 - CCRT + Zeolite SCR + Ammonia Slip Catalyst



TECHNOLOGY OPTIONS AND BENEFITS



Selective Catalytic Reduction (SCR)

Ozark / Raley's Truck 1555 (2.5g NOx engine)



System Description			
Vehicle	2005 Kenworth	Injector type	Grundfos
Engine	2005 CUM ISX 400 Hp 14 l	Sensors	IFM Efector Kavlico
CRT	8.5 l DOC	Primary Purpose	Performance evaluation/ Verification
	22l 200 cpsi coated filter	Installed	Aug 2007
SCR	25.5 l Zeolite	Other	
	4.2 l ASC		

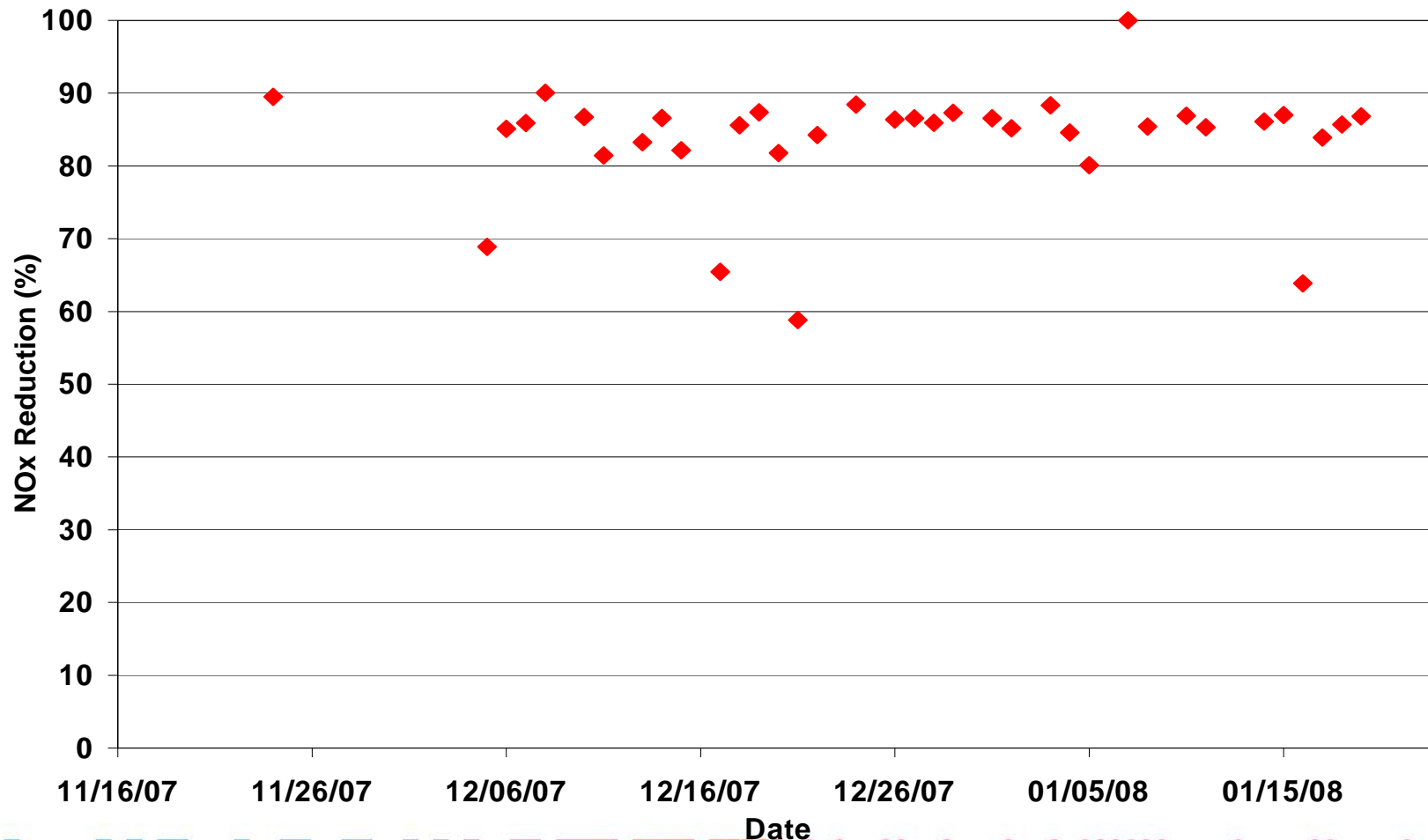
11/16/2007 - 1/23/2008	
NOx Reduction	80.6%
Hours run	191.3
Overall CRT P200	78.0%
Overall SCR P200	81.1%



TECHNOLOGY OPTIONS AND BENEFITS



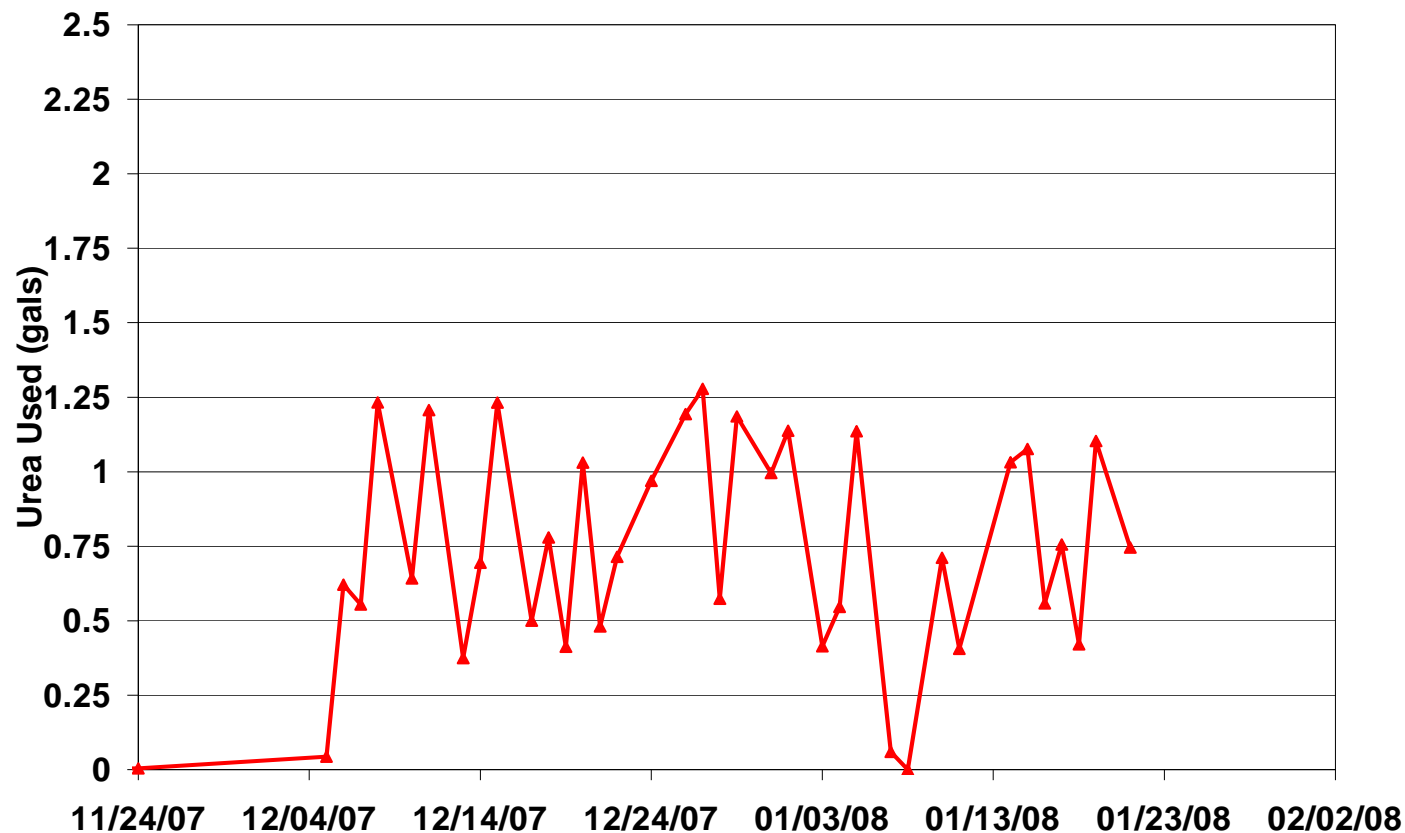
Daily Nox Conversion
1 minute Average data Summed for each day



TECHNOLOGY OPTIONS AND BENEFITS



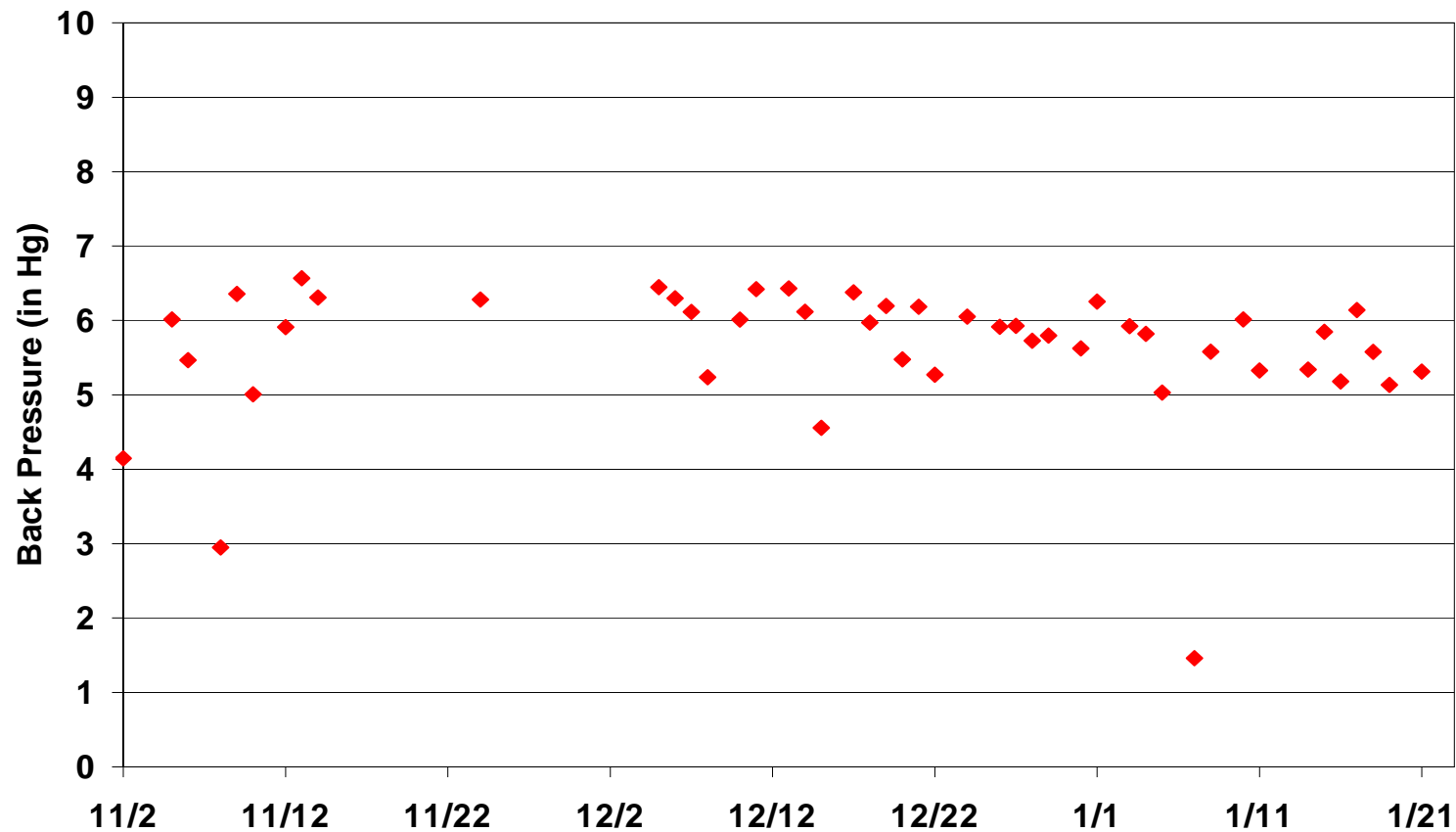
Urea usage for Truck 1555 - The average amount of urea injected every minute is recorded and added up for each day.



TECHNOLOGY OPTIONS AND BENEFITS



Backpressure for Truck 1555 - The peak backpressure readings measured each minute are averaged daily.



- DOC's – Verified EPA, CARB
- Partial Filters – Verified EPA, CARB
- Passive Filters – Verified EPA, CARB
- Active Filters – Electric: verified EPA, CARB
 - Burner: Verified CARB
- Lean NOx Catalyst – Verified CARB
- EGR – Verified CARB
- SCR – EPA/CARB Verified within 6 Months
- LNT – Not a Retrofit technology

